



# Phytoplankton in a tropical estuary, Northeast Brazil: composition and life forms

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**Abstract:** We aimed verify the composition of the phytoplankton community and this life forms that occur in the Capibaribe River estuary, Pernambuco, Brazil. This is a highly impacted ecosystem by anthropic activities. We collected samples of the phytoplankton community at three stations, during three months of each season: dry, from October to December 2010; rainy, from May to July 2011. We collected samples during the low and high tide, at the spring tide. We classified the species based on life forms. We identified 127 taxa, and the majority of species were freshwater planktonic form (FP; 30%), followed by marine oceanic planktonic (MOP; 25%), marine neritic tichoplanktonic (MNT; 22%) and planktonic (MNP; 19%), and tichoplanktonic estuarine (TE; 3%) and freshwater (TF; 1%). The majority of species identified were diatoms, since it assumes the most variability of life forms, therefore enabling its presence in the different portions at the estuary.

**Key words:** diatoms; freshwater; marine; plankton; tichoplankton

## INTRODUCTION

Estuaries are high dynamic ecosystems affected by marine and limnetic conditions, such as changes in the river flow and marine tides, enabling different characteristic zones along the estuary. Thereby, it is observed great variations of the environmental parameters (Miranda et al. 2002). As a result, the phytoplankton community rapidly responds to these environmental changes (Cloern and Jassby 2010). Phytoplankton are one of the main primary producers in aquatic ecosystems, as well as is considered excellent bioindicators of environmental quality (Reynolds 2006).

The different life forms in the phytoplankton species are dependent, in general, on their response to the heterogeneity of habitats, besides the tolerance to

oscillations in the environmental, which can resuspend or deposit cells on the bottom. The knowledge of composition and life forms of the biotic communities is a necessary tool to understand the mechanism and the ecological importance of aquatic ecosystems (Eskinazi-Leça et al. 2004; Cloern and Jassby 2010).

In this context, our study aimed to analyze the composition of the phytoplankton community and the main life forms of species occurring in the Capibaribe River estuary (Pernambuco), which is an important aquatic body in Northeast Brazil.

## MATERIALS AND METHODS

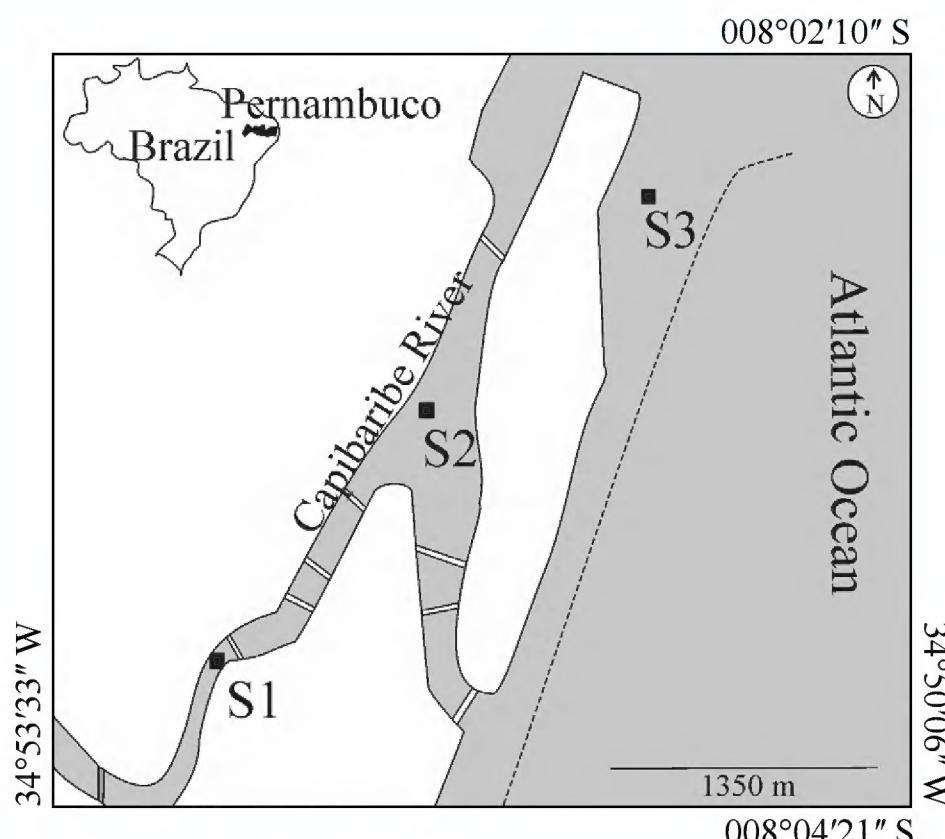
### Study Area

The Capibaribe River estuary is located in the downtown of the Recife City (Pernambuco state, Northeast Brazil; Figure 1). Because it is located in an area of high degree of urbanization, waters are eutrophized and strongly affected by anthropic activities, mainly due to discharge of domestic and industrial effluents. As consequence, occur high concentrations of ammonia, phosphorus, heavy metals, and thermotolerant coliforms, and turning the levels of dissolved oxygen undetectable (SRH 2010).

### Data sampling and analysis

We collected samples for phytoplankton analysis at three sites along the estuary: upstream (S<sub>1</sub>), downstream (S<sub>3</sub>), and one intermediate site (S<sub>2</sub>) along the river. We conducted sampling during three months of each climatic seasons, in the dry (October to December 2010) and rainy (May to July 2011) season, and during high and low tide in the same day, in spring tide.

We collected phytoplankton from the Capibaribe River estuary through superficial horizontal hauls (plankton net of 64 µm mesh size), for 3 minutes. We fixed samples ( $n = 36$ ) in neutral formaldehyde (Newell and Newell 1963), for subsequent identification and counting by optic microscopy.



**Figure 1.** Capibaribe River estuary (Pernambuco state, Brazil), where is located the sampling sites (S1, S2, and S3).

We identified the species based on specific references, as Peragallo and Peragallo (1897-1908), Husted (1961-1966), Cupp (1943), Silva-Cunha and Eskinazi-Leça (1990), Tomas (1993), Sournia (1986), Balech (1988), Licea et al. (1995), Desikachary (1959), Mizuno (1968). When necessary, we observed the chloroplasts using a contrast phase system, and to better identification of the diatom frustule ornateations we referenced Carr et al. (1986). We used the taxonomic classification system of Guiry and Guiry (2012).

We classified the life forms to only ones the organisms identified until species level. For diatoms,

this classification was based on Torgan and Biancamano (1991), Moreira Filho et al. (1990; 1994/95; 1999), and Silva-Cunha and Eskinazi-Leça (1990). For the remaining groups we used the online database from Guiry and Guiry (2012) and Eskinazi-Leça et al. (2013). We considered the following classes: marine oceanic planktonic (MOP), marine neritic planktonic (MNP), marine neritic tichoplanktonic (MNT), tichoplanktonic estuarine (TE), tichoplanktonic freshwater (TF), and freshwater planktonic (FP).

## RESULTS

As result, we registered 128 taxa, overwhelming dominated by phylum Ochrophyta (diatoms), which formed 54% of the total, followed by the phyla Cyanobacteria (cyanobacteria, 18%), Chlorophyta (chlorophytes, 13%), Myzozoa (dinoflagellate, 7%), Euglenozoa (euglenophyte, 5%) and Charophyta (charophyte, 3%).

The majority of species identified showed the life forms compatible with FP, corresponding to 30% of the total and consisting mainly of species of chlorophytes and cyanobacteria. Species of MOP represented 25% of the total, followed by MNT and MNP, with 22% and 19%, respectively. Ultimately, species of TE and TF were represented with 3% and 1% of the total, respectively (Table 1). All dinoflagellates identified in the Capibaribe River estuary marine and planktonic life forms, and also other 26 species of diatoms (Table 1). Only *Fragilaria capucina* Desmazières were part of the FT category (Table 1). Two species of diatoms were part of the TE, *Terpsinoë musica* Ehrenberg and *Gyrosigma balticum* (E.) Rabenhorst.

**Table 1.** Taxa identified in the Capibaribe River estuary and this life form. Codes: (MNT) Marine Neritic Tichoplanktonic; (MNP) Marine Neritic Planktonic; (MOP) Marine Oceanic Planktonic; (FT) Freshwater Tichoplanktonic; (FP) Freshwater Planktonic; (TE) Tichoplanktonic Estuarine.

Taxa	Life form		Taxa	Life form
<b>PHYLUM CYANOBACTERIA</b>				
<b>Class Cyanophyceae</b>			<b>Order Oscillatoriales</b>	
<b>Order Nostocales</b>			<i>Lyngbya</i> sp.	
<i>Anabaena</i> sp.			<i>Oscillatoria princeps</i> Vaucher ex Gomont	FP
<i>Aphanizomenon</i> sp.			<i>Oscillatoria</i> sp1	
<i>Cylindrospermopsis raciborskii</i> (W.) Seenayya & S. Raju	FP		<i>Oscillatoria</i> sp2	
<i>Nostocales</i> undetermined			<i>Phormidium</i> sp1	
<i>Richelia intracellularis</i> J. Schmidt	MOP		<i>Phormidium</i> sp2	
<b>Order Chroococcales</b>			<i>Phormidium</i> sp3	
<b>Chroococcales</b> undetermined			<i>Planktothrix agardhii</i> (G.) Anagnostidis & Komárek	F
<i>Chroococcus dispersus</i> (K.) Lemmermann	FP		<i>Planktothrix isothrix</i> (S.) Komárek & Komárová	F
<i>Microcystis aeruginosa</i> (K.) Kützing	FP			
<b>Order Synechococcales</b>				
<i>Coelomorion</i> sp.			<b>PHYLUM EUGLENOZOA</b>	
<i>Merismopedia punctata</i> Meyen	FP		<b>Class Euglenophyceae</b>	
<b>Order Pseudanabaenales</b>			<b>Order Euglenophyceae</b>	
<i>Geitlerinema unigranulatum</i> (R. N. S.) Komárek & Azevedo	FP		<i>Colacium</i> sp.	
<i>Geitlerinema</i> sp.			<b>Order Eutreptiales</b>	
<i>Pseudanabaena</i> sp.			<i>Eutreptiella</i> sp.	
<i>Spirulina subsalsa</i> Oersted	FP		<b>Order Euglenales</b>	
<i>Spirulina</i> sp.			<i>Euglena acus</i> (O. F. M.) Ehrenberg	FP

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**Table 1.** Continued.

Taxa	Life form	Taxa	Life form
<b>PHYLUM MYZOOZA</b>		<b>Thalassiosirales undetermined</b>	
<b>Class Dinophyceae</b>		<b>Order Lithodesmiales</b>	
<b>Order Dinophysiales</b>		<i>Ditylum</i> sp.	
<i>Dinophysis caudata</i> Saville-Kent	MNP	<i>Helicotheca tamesis</i> (S.) Ricard	MNP
<b>Order Gonyaulacales</b>		<b>Order Rhizosoleniales</b>	
<i>Neoceratium extensum</i> (G.) Gomez, Moreira & Garcia	MNP	<i>Guinardia flaccida</i> (C.) Peragallo	MOP
<i>Neoceratium furca</i> (E.) Gomez, Moreira & Garcia	MNP	<i>Guinardia striata</i> (S.) Hasle	MOP
<i>Neoceratium fusus</i> (E.) Gomez, Moreira & Garcia	MOP	<i>Proboscia alata</i> (B.) Sundström	MOP
<i>Neoceratium macroceros</i> (E.) Gomez, Moreira & Garcia	MOP	<i>Rhizosolenia setigera</i> Brightwell	MOP
<i>Neoceratium trichoceros</i> (E.) Gomez, Moreira & Garcia	MOP	<i>Rhizosolenia styliformis</i> T.Brightwell	MOP
<i>Neoceratium tripos</i> (M.) Gomez, Moreira & Garcia	MOP	<b>Order Leptocylindrales</b>	
<b>Order Peridiniales</b>		<i>Leptocylindrus danicus</i> Cleve	MNP
<i>Protoperidinium</i> sp1		<b>Order Paraliales</b>	
<i>Protoperidinium</i> sp2		<i>Paralia sulcata</i> (E.) Cleve	MNT
<b>PHYLUM OCHROPHYTA</b>		<b>Class Bacillariophyceae</b>	
<b>Class Coscinodiscophyceae</b>		<b>Order Bacillariales</b>	
<b>Order Aulacoseirales</b>		<i>Bacillaria paxillifera</i> (O. F. M.) Marsson	MOP
<i>Aulacoseira granulata</i> (E.) Simonsen	FP	<i>Cylindrotheca closterium</i> (E.) Reimann & Lewin	MNT
<b>Order Coscinodiscales</b>		<i>Nitzschia insignis</i> Gregory	MNT
<i>Actinptychus splendens</i> (S.) Ralfs ex Pritchard	MNT	<i>Nitzschia lorenziana</i> Grunow	MNT
<i>Coscinodiscus centralis</i> Ehrenberg	MOP	<i>Nitzschia sigma</i> (K.) W.Smith	MNT
<i>Coscinodiscus kutzning</i> Grunow	MOP	<i>Nitzschia</i> sp.	
<i>Coscinodiscus nitidus</i> W.Gregory	MNP	<i>Pseudo-nitzschia pungens</i> (Grunow ex Cleve) Hasle	MNP
<i>Coscinodiscus oculus-iridis</i> (E.) Ehrenberg	MNP	<b>Order Suriellales</b>	
<i>Coscinodiscus</i> sp1		<i>Campylodiscus clypeus</i> (E.) Ehrenberg ex Kützing	MNT
<i>Coscinodiscus</i> sp2		<i>Entomoneis alata</i> (E.) Ehrenberg	MOP
<i>Coscinodiscus</i> sp3		<i>Suriella febigerii</i> Lewis	MNT
<b>Order Chaetoceratales</b>		<b>Order Naviculales</b>	
<i>Bacteriadrum delicatulum</i> Cleve	MOP	<i>Gyrosigma balticum</i> (E.) Rabenhorst	TE
<i>Chaetoceros atlanticus</i> Cleve	MOP	<i>Navicula</i> sp.	
<i>Chaetoceros brevis</i> F.Schütt	MNP	<i>Pinnularia</i> sp.	
<i>Chaetoceros compressus</i> Lauder	MOP	<i>Pleurosigma</i> sp1	
<i>Chaetoceros curvisetus</i> Cleve	MNT	<i>Pleurosigma</i> sp2	
<i>Chaetoceros lorenzianus</i> Grunow	MNP	<b>Naviculales undetermined</b>	
<i>Chaetoceros peruvianus</i> Brightwell	MOP	<b>Class Fragilariphycaceae</b>	
<i>Chaetoceros</i> sp1		<b>Order Lichmophorales</b>	
<i>Chaetoceros</i> sp2		<i>Lichmophora abbreviata</i> Agardh	MNT
<b>Order Hemiaulales</b>		<i>Lichmophora</i> sp.	
<i>Bellerochea malleus</i> (B.) Van Heurck	MNP	<b>Order Thalassionematales</b>	
<b>Order Triceratiales</b>		<i>Thalassionema frauenfeldii</i> (G.) Hallegraeff	MOP
<i>Odontella aurita</i> (L.) Agardh	MNT	<i>Thalassionema</i> sp.	
<i>Cerataulus turgidus</i> (E.) Ehrenberg	MNT	<b>Order Melosirales</b>	
<i>Dimerogramma</i> sp.		<i>Melchersiella hexagonalis</i> Kützing	MNP
<i>Triceratium pentacrinus</i> (E.) Wallich	MNT	<b>Order Rhabdonematales</b>	
<i>Triceratium broeckii</i> G. Leuduger-Fortmorel	MNT	<i>Rhabdonema punctatum</i> (Harvey & Barley) Stodder	MNT
<b>Order Biddulphiales</b>		<i>Order Striatellales</i>	
<i>Biddulphia biddulphiana</i> (S.) Boyer	MNT	<i>Grammatophora marina</i> (L.) Kützing	MOP
<i>Terpsinoë musica</i> Ehrenberg	TE	<b>PHYLUM CHLOROPHYTA</b>	
<b>Class Fragilariphycaceae</b>		<b>Class Chlorellaceae</b>	
<b>Order Fragilariales</b>		<b>Chlorellaceae undetermined</b>	
<i>Asterionellopsis glacialis</i> (C.) Round	MNP	<b>Class Trebouxiophycaceae</b>	
<i>Fragilaria capucina</i> Desmazières	FT	<b>Order Chlorellales</b>	
<i>Fragilaria</i> sp.		<i>Actinastrum hantzschii</i> Lagerheim	FP
<i>Synedra</i> sp.		<i>Micractinium pusillum</i> Fresenius	FP
<b>Order Thalassiosirales</b>		<i>Oocystis</i> sp.	
<i>Cyclotella glomerata</i> Bachmann	FP	<b>Order Trebouxiophycaceae</b>	
<i>Cyclotella</i> sp.		<i>Crucigenia tetrapedia</i> (K.) Kuntze	FP
<i>Lauderia</i> sp.			
<i>Skeletonema costatum</i> (G.) Cleve	MNP		
<i>Thalassiosira eccentrica</i> (E.) Cleve	MNT		
<i>Thalassiosira</i> sp.			

*Continued*

**Table 1.** Continued.

Taxa	Life form	Taxa	Life form
<b>Class Ulvophyceae</b>		<b>Order Chlamydomonadales</b>	
<b>Order Cladophorales</b>		<i>Pandorina morum</i> (O.F.M.) Bory de Saint-Vincent	FP
<i>Cladophora</i> sp.		<b>PHYLUM CHAROPHYTA</b>	
<b>Class Chlorophyceae</b>		<b>Class Charophyceae</b>	
<b>Order Sphaeropleales</b>		<b>Order Charales</b>	
<i>Desmodesmus maximus</i> (West & West) Hegewald	FP	<i>Chara</i> sp.	
<i>Monoraphidium</i> sp.	FP	<b>Class Conjugatophyceae</b>	
<i>Pediastrum boryanum</i>	FP	<b>Order Desmidiales</b>	
<i>Pediastrum duplex</i> Meyen	FP	<i>Closterium</i> sp.	
<i>Pediastrum</i> sp.	FP	<i>Staurastrum</i> sp.	
<i>Scenedesmus acutus</i> Meyen	FP	<b>Order Zygnematales</b>	
<i>Scenedesmus dimorphus</i> (T.) Kützing	FP	<i>Spirogyra</i> sp.	
<i>Scenedesmus obliquus</i> (T.) Kützing	FP		
<i>Scenedesmus quadricauda</i> Chodat	FP		

## DISCUSSION

In tropical estuary ecosystems diatoms are the main components of the planktonic flora (Fujita and Odebrecht 2007; Masuda et al. 2011; Borges et al. 2012). Studies with phytoplankton species demonstrated that the predominance of diatoms in estuarine ecosystems is not only due to its high rate of division, but also to its euryhaline ability (Ribeiro et al. 2003).

More recent approaches focusing the phytoplankton community in ecosystems nearby of the Capibaribe River have shown that diatoms are the main organisms of the community. It is explained by the higher levels of silicate in these waters and thus, its benefits the diatom population (Santiago et al. 2010; Borges et al. 2012). In addition, our results suggest that the greater occurrence of diatoms in estuaries, comparing with other groups, is due to the different life forms that this population can assume (Table 1).

Many species that are present in estuaries are originally from the freshwaters, such as chlorophyceans and cyanobacteria species. These species are transported downstream by the river's flow (Masuda et al. 2011). The occurrence of some freshwater cyanobacteria species in our study show that these species are present in some freshwater ecosystems in Northeast Brazil, mostly in rivers and reservoirs that are components of the watershed of the Capibaribe River (Dantas et al. 2012).

On the other hand, dinoflagellates identified during our study were essentially marine and planktonic. These organisms are present in the estuarine environment due to the tide regime, which is responsible for their transport into the estuary (Trigueros and Orive 2000). *T. musica* and *G. balticum* are tycoplanktonic estuarine diatoms. Both species are present in other tropical estuaries in Brazil (Fujita and Odebrecht 2007; Leão et al. 2008; Santiago et al. 2010; Masuda et al. 2011), while *F. capucina* is the only tycoplanktonic freshwater form in the present study, commonly reported in other benthonic substrates (Roberts et al. 2004; Antoniades

et al. 2005). The three diatoms mentioned are in water column due to the high dynamism of the estuarine ecosystem, which induces mixture and resuspension of organisms from the bottom (Fujita and Odebrecht 2007).

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